"Intravascular Pump"

This invention relates to heart pumps, and in particular, to an intravascular pump which can be used to assist the operation of a patient's heart, when it is in a weak condition.

Various types of intravascular heart pumps are known, but these generally require major surgery, to enable them to be suitably located in an appropriate position in the heart. The present invention seeks to introduce a heart pump which is capable of providing significant assistance to the heart, whilst reducing the degree of invasive surgery required to introduce it into the operative position.

The present invention provides an intravascular bi-directional pump which is adapted to be located in the upper aorta, whereby it can assist the left ventricle to eject in the forward direction during systole, so as to off-load the heart, and also pump an adequate amount in the reverse direction, during diastole to secure coronary flow.

Preferably, the pump is placed either in the ascending aorta, just distal to the aortic valve leaflets, or in the upper descending aorta.

Preferably the pump is mounted (hung) into a stent that can be deployed by means of a balloon. The latter can be withdrawn after the stent has been established in situ. Both the stent and the pump attached to it will then remain inside the aorta.

The pump may be inserted by either

1. Surgically slitting the aorta at the preferred position (see above) and placing the pump.

2. Inserting the pump subcutaneously from the groin or lower abdomen, and advancing it into the aorta until it reaches the preferred position.

Various type of pumps may be utilised to provide the functions required, such as centrifugal, positive displacement or axial.

The pump may be powered by a direct connection, such as a wire running through the aortic wall and the skin, and connected to an outside battery, or alternatively by means of a wireless connection, for example using induction coils.

Some embodiments of the invention will now be described, by way of example, with reference to the accompanying drawings in which:

Figure 1 is a diagrammatic view of the heart, showing the upper aorta;

Figure 2 is a schematic view of a positive displacement pump;

Figure 3 is a schematic view of an axial pump;

Figure 4 is a schematic view of a first type of centrifugal pump, and

Figure 5 is a schematic view of a second type of centrifugal pump.

Figure 6a is a diagrammatic cross-section through an aorta showing a first type of pump mounting; and

Figure 6b is a diagrammatic cross-section through an aorta showing a second type of pump mounting.

Referring firstly to Figure 1, the heart is illustrated diagrammatically at 2, and the ascending aorta is indicated at 4. A suitable type of heart pump (as described in more detail below) is inserted in the region 4, either by slitting the aorta at the preferred position, or by inserting the pump from the groin or lower abdomen, and advancing it along the aorta until it reaches the preferred position. Preferably, this is achieved using a known "angioplasty" type of technique. This involves mounting the pump in a stent and delivering it on a deflated balloon to the desired position, after which the balloon is withdrawn. Both the stent and the pump then remain inside the aorta. Preferably the pump is detachably mounted on the stent so that it can be pulled out of the body (for example via the groin) in case it should become faulty. For this purpose a releasable attachment mechanism may be arranged between the pump and the stent.

Figure 2 illustrates a first possible type of pump that may be utilised for the invention, which is a simple cylindrical positive displacement pump, having a piston 6

and flow outlets 8 and 10 at either end. By means of suitable switchable one way valves, for example in the piston, the pump can be arranged to move fluids in either direction.

Similarly, Figure 3 illustrates an axial pump, having a screw type rotor 12, so that the direction of pumping can be reversed, by reversing the direction of rotation of the rotor.

In the case of the Figure 2 or Figure 3 pumps, the direction of pumping will be reversed, so that a calculated amount is caused to flow forward towards the periphery, and backwards towards the heart in systole and diastole respectively.

Figure 4 illustrates an alternative type of centrifugal pump, having a rotary impeller 14 mounted in the casing 16, so that the inlet region 18 is at the axis of the impeller, whilst the outlet 20 is at the circumference. In a pump arrangement of this kind, if a pair of impellers are arranged to rotate about the same axis 30, as illustrated diagrammatically in the view of Figure 5, the pump can be made to operate bi-directionally, depending upon which of the rotors 26 or 28 is driven at any given time. Thus if the rotor 26 is driven, whilst the rotor 28 is left stationary, fluid will be drawn into the inlet 24, past the stationary vanes of the rotor 28, and axially into the central region of the driven rotor 26 so that aperture 22 becomes an outlet. In a similar way, if the rotor 28 is driven, the aperture 22 becomes an inlet, whilst the aperture 24 becomes an outlet.

Alternatively, by adding a suitably oriented additional inlet/outlet duct to the simple centrifugal pump casing of Figure 4, and closing off the axial inlet, the flow can be reversed simply by reversing the direction of rotation of the fan blades, provided that they are also suitably oriented.

The pump can be powered either by:

1. Wireless power transmission, where the required power needed is transferred to the rotor wirelessly from outside the body by means of coils placed on the skin, or

2. Using a wire that runs through the aortic wall and the skin to be connected to an outside-the-body battery that can be charged/replaced or disconnected.

In order to allow the pump to be removed from the body in case of malfunction, it may be detachably mounted on the stent as illustrated in the cross-sectional views of Figures 6a and 6b. Figure 6a illustrates an arrangement in which a stent 32 has been inserted in the artery 34 and carries the pump 36 on a mounting 38 to which it is connected by means of a clip-on hanger arrangement. Alternatively, as shown in Figure 6b, the pump 36 can be carried on an electromagnetically actuated base 40 so that it is released by disconnecting the power source. In either case this allows the pump to be removed whilst leaving the stent "in-situ".